Exploring musical interaction between a teacher and pupil, and her evolving musicality, using a music-theoretical Approach

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Introduction

In the context of a single case study, this paper explores the musical interaction between a pupil and teacher, and the pupil's evolving musicality, using the music-theoretical approach to the cognition of musical structure set out by Ockelford (2002, 2004, 2005a, 2005b, 2006a) – 'zygonic theory'. The object of the study is a vocal improvisation by 'K', a four-and-a-half-year-old girl with septo-optic dysplasia,[i] which was previously videoed and transcribed (see Ockelford, Pring, Welch & Treffert, 2005; Ockelford, 2006b). The improvisation was initially led and then accompanied on the piano by the author ('AO'), who at the time was K's music teacher. The musical relationships that are identified between various elements within and beyond K's improvisation provide, it is argued, a unique insight into her evolving musicality and may even serve as proxy measures of her social interaction in the context of music-making. It is hoped that the analytical techniques set out in the course of the paper may have wider relevance in educational and therapeutic contexts that use music as a medium of communication and socialization.

The session

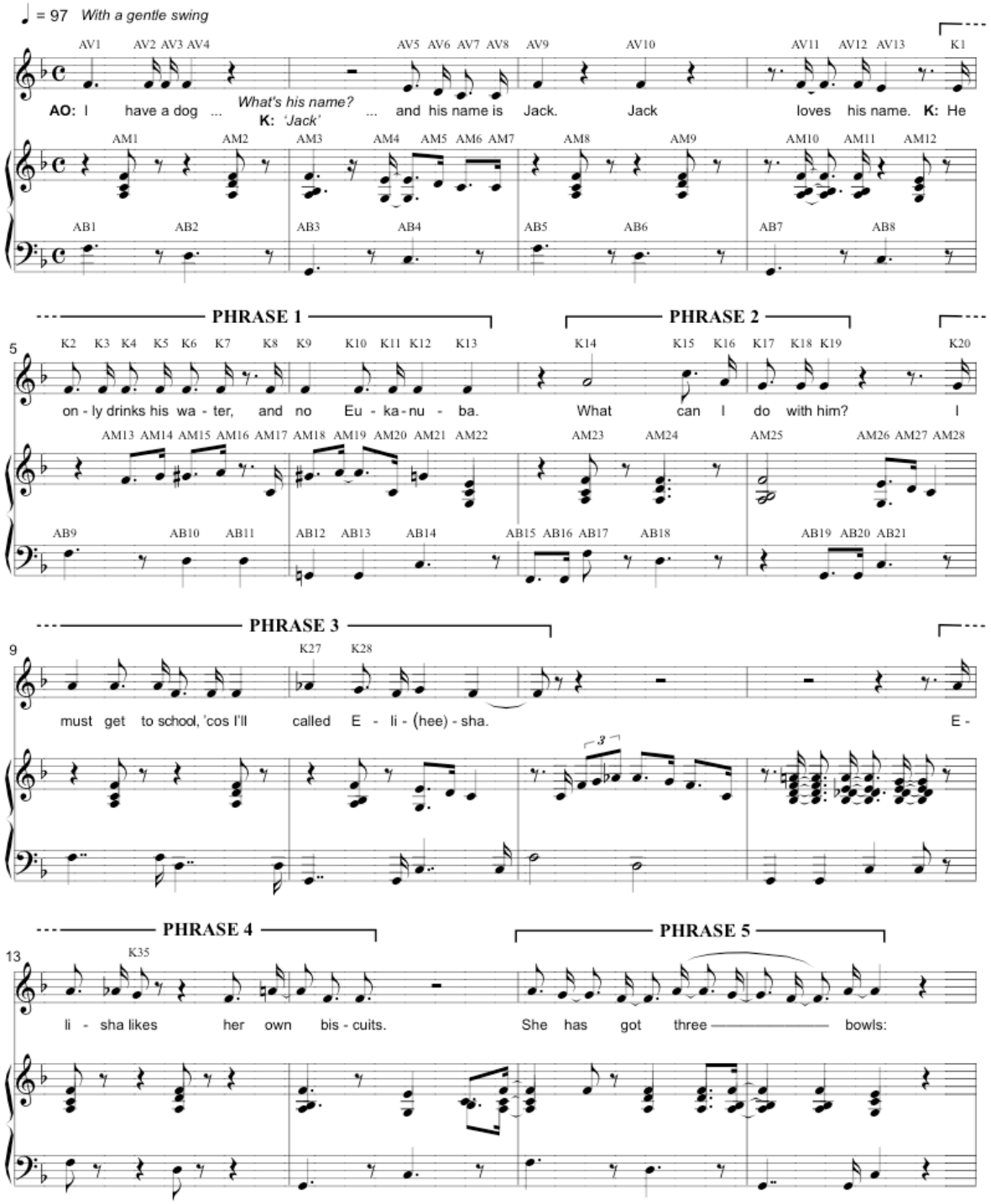
The session with K was originally intended to enable AO to assess her musical abilities and potential.[ii] The assessment had been requested by K's class teacher, who had observed that her new pupil particularly enjoyed singing and that (as far as she was able to judge) K's efforts appeared to be unusually advanced for a child of her age. All that was known of K's musical background was that she had a small keyboard at home, which apparently kept her occupied for significant periods of time, although she had never received any formal music tuition. AO began the session by suggesting to K that she might like to sing something, whereupon she immediately set off unaccompanied with *Supercalifragilisticexpialidocious* from *Mary Poppins*. K's singing was enthusiastic though somewhat raucous. Despite the fact that her vocal technique was limited, which meant that her intonation was not always perfect, K's rendition had a secure tonal centre (the key of D), which was established without reference to a fixed pitch. K evidently relished the novel experience of making music with someone listening, and she was pleased to repeat the song with great gusto at an even faster tempo, this time with a piano accompaniment.

It was immediately evident that K was a natural and uninhibited young performer, who thoroughly enjoyed making music and was capable of communicating forcefully through sound. The fact that her rendition began recognizably in the key of D major (although K was unaware of this or any other formal musical concepts or specialized terminology) and remained in that key (notwithstanding the immaturity of her vocal production) indicated that K was likely to have 'absolute pitch' ('AP').[iii] In addition, she exhibited a reliable sense of rhythm

that was nonetheless flexible enough to accommodate different tempi. A number of issues remained to be resolved, however. How effectively was she able to process harmony, for example? Could she create her own music? And if so, at what level was K capable of assimilating and developing material that was provided and fashion this into a coherent structure within a recognizable stylistic framework? Answers to these questions were sought by suggesting that K should make up a new song about her pet dogs (Jack and Elisha), of which she was known to be particularly fond. AO played four chords – F major, D minor, G minor[9] and C major – on the piano with a gentle swing rhythm, and added a simple vocal melody to set the scene. After two iterations of the sequence, K intuitively took the lead and, against the continuing four-chord ostinato, improvised a song that lasted for around 90 seconds.

AO's initial impression, as the teacher-accompanist, was of an unfolding extemporization of genuine musical expressivity within a continuously evolving but coherent musical structure. It was clear that K had an active musical mind that was able to create new material intuitively, quickly and confidently within a broadly familiar style. Beyond these immediate reactions, however, the taped record of the session meant that it was subsequently possible to transcribe and analyse K's efforts systematically in relation to a number of criteria, which enabled the musical interaction to be quantified on a moment-to-moment basis, and aspects of K's music-making to be profiled. These criteria were developed from the author's theory of how music intuitively 'makes sense' and can convey meaning (Ockelford, 2005a, 2005b). An introduction follows.

I Have a Dog



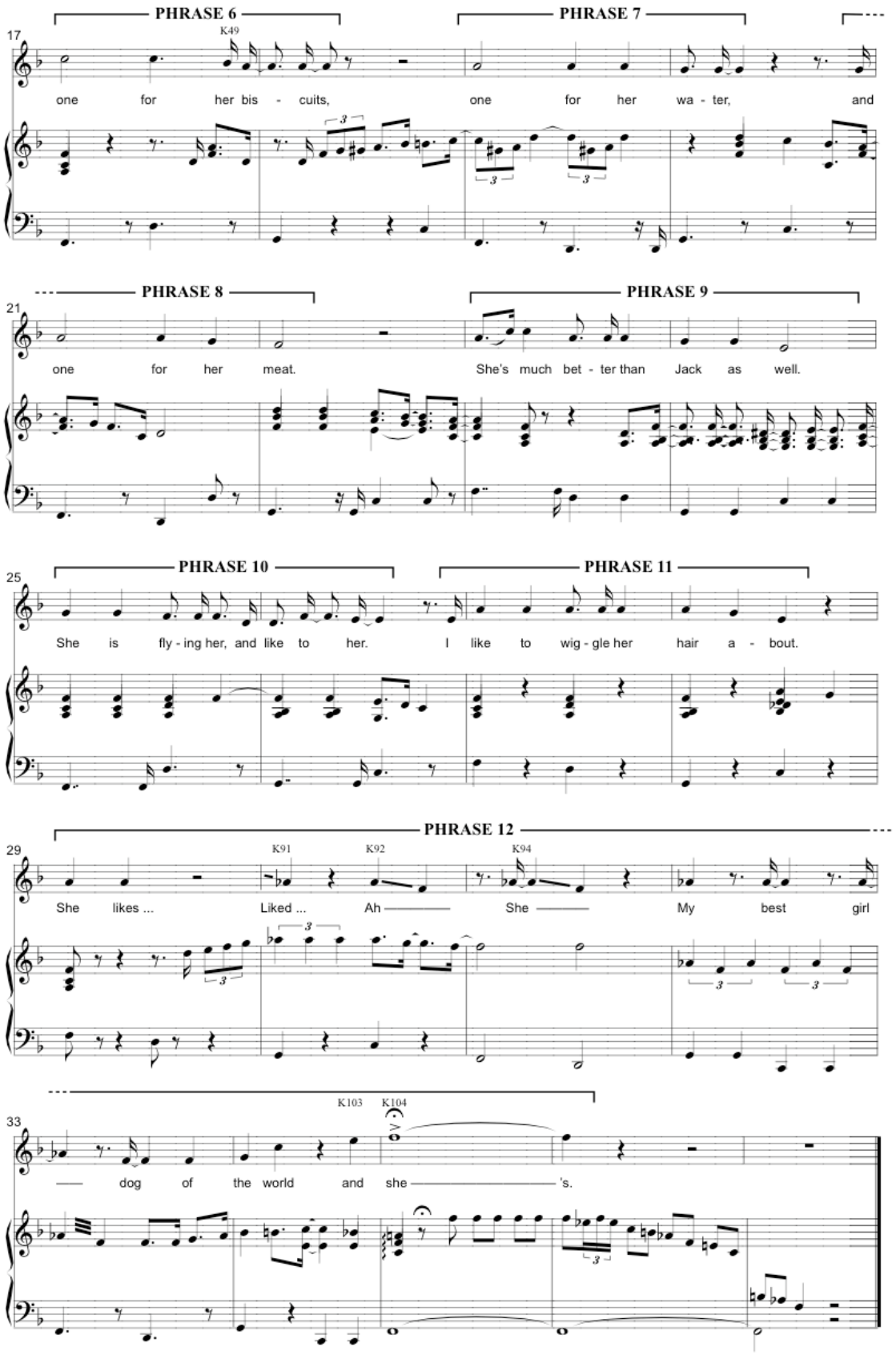


Figure 1

An introduction to zygonic theory

Zygonic theory (in essence, a set of music-theoretical principles that are embedded within cognitive science) holds that musical coherence is based on a sense of *derivation*, whereby any given aspect of musical sound – a particular pitch, harmony, tonality, interonset interval, duration or meter, for example – is felt to *imitate* another (something which typically occurs non-consciously). Each of these features has the potential to induce a range of emotional responses, and the sense of derivation that exists between them enables a kind of abstract aesthetic narrative to be built up in the course of listening to a piece – rather like hearing a story that is devoid of literal meaning.[iv] The cognition of derivation between musical elements is predicated on the presence of 'interperspective relationships'[v] – cognitive constructs through which, it is hypothesised, percepts may be compared (cf. Krumhansl, 1990, p. 3). Such relationships potentially exist between any features of musical events. In most circumstances they are formulated unthinkingly, passing listeners by as a series of qualitative experiences. However, through introspection, interperspective relationships may be captured conceptually and assigned values, commonly expressible as a difference or ratio.

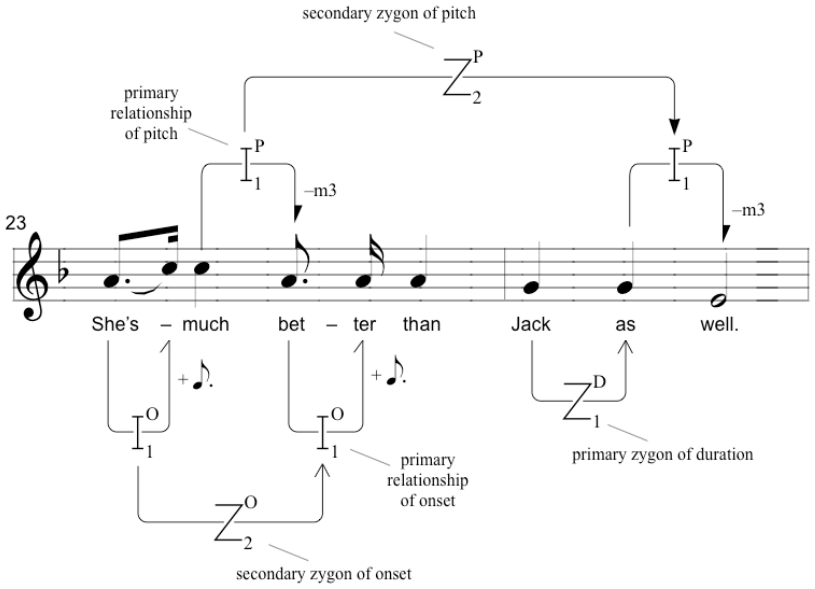


Figure 2

Figure 2 shows how interperspective relationships may be symbolized by an arrow with the letter 'I' superimposed. Superscripts indicate the features concerned, each represented by its initial letter – here 'P' for 'pitch' and 'O' for 'onset'. Relationships can exist at different *levels*, with 'primary' relationships potentially linking percepts directly, 'secondary' relationships connecting primaries, and 'tertiary' relationships comparing secondaries (Ockelford, 2002). The level of a relationship is indicated by the appropriate subscript (here, '1' in each case). The values of the pitch relationships (shown near the arrowheads as '–m3') have two components, 'polarity' (which here is negative, showing that the intervals are descending) and 'magnitude' (a minor 3rd). Similarly, the values of the relationships of onset indicate both temporal polarity and magnitude (a dotted quaver).[vi]

Interperspective relationships through which imitation is cognized are deemed to be of a special type, termed 'zygonic' (Ockelford, 1991, p. 140ff).[vii] Zygonic relationships, or 'zygons', are depicted using the letter 'Z'. In Figure 2, the primary zygonic relationship of duration ('D') reflects the apparent derivation of the note-length used for the word 'as' from that pertaining to the preceding 'Jack'. The secondary zygons of pitch and onset (indicated through the subscripts '2') show imitation at a more abstract (intervallic) level. Observe the use of *full* arrowheads, which signify relationships between values that are the same. *Half* arrowheads are indicative of difference, and are used in a zygonic context to show approximate imitation.[viii]

This music-theoretical framework will be used to analyse K's improvisation in relation to the three potential sources of material from which she could draw: (a) the unfolding melody, as initiated by AO and subsequently taken up by K; (b) the piano accompaniment provided by AO; and (c) other pieces in similar style.

K's song

Does K's song 'make sense' as a piece of music – and, if so, through what structural means? According to zygonic theory, musical coherence requires at least one salient feature from each event to derive from another or others.[ix] A full zygonic analysis of K's song (which is too extensive to be reproduced here)[x] shows that this is indeed the case, and confirms the informal observation that successive notes do not pass by as isolated entities, but sound logically connected to each other through similarities in pitch or rhythm which bind them together in the mind to form short melodic 'chunks'. As we shall see, these chunks are themselves linked through various forms of sameness and similarity. Here, an analysis of K's first phrase will suffice to illustrate the principles involved.[xi]

K's song begins as she picks up on the fourth octave E that AO's vocal line leaves in the air, and which is reinforced in his accompaniment. From here, K moves back to the adjacent F, following the change from tonic to dominant harmony, which she would have been able to anticipate from the same harmonic transition between bars 2 and 3. This opening melodic interval is a retrograde version of the ending of AO's last vocal phrase – illustrating how, from the outset, K takes the material that is offered and stamps her authority on it. K's initial F is followed by 11 others, together constituting a pitch structure of the simplest kind (potentially derived through a network of identical primary zygonic relationships that are known as a 'constant system'; Ockelford, 1993, p. 180ff). This repeated series of notes, which at first appears to overextend itself against the accompanying harmonies (conflicting with the concluding dominant chord in the second half of bar 6), could be heard as a device for K to buy time while deciding what to do next. However, analysis shows that the series of Fs actually grows organically from the preceding material, deriving from two sources: the pitches echo the initial repetitions of the melody, and the rhythm adopts the dotted-quaver/semiquaver pattern first heard in the second half of bar 2. This means that K took two distinct elements from the opening phrases of the melody (supplied by AO) and fused them in her continuation, a form of musical development typical of many styles that simultaneously offers coherence and variety.

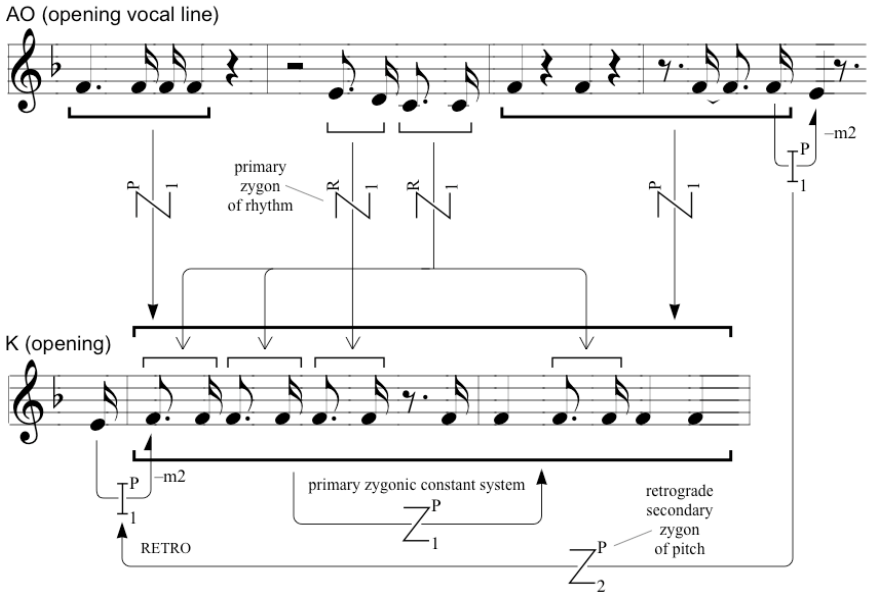


Figure 3

K's forceful delivery of the repeated pitches adds to the sense that she is asserting her place in the partnership that is about to unfold: both musically and socially, building a foundation for the action to come. This starts immediately: in the very next phrase (bar 7), there is a sense of release as K's melody springs up from the constraints of the opening repetitions using a new, syncopated rhythm. Despite the sense that things are moving off in a new direction, though, both pitch and rhythm again derive logically from what has gone before: the 'dotted' motive again pressed into service and two similar ascending melodic intervals (from F to A, and A to C) deployed to straddle the phrases. This method of connecting chunks, through secondary zygonic relationships – rather like using a musical 'ladder' to link different ideas – is one that K adopts a number of times (for example, between bars 16/17 and 22/23). Her other favored approach is to use a primary zygonic relationship – taking a pitch at or near the end of a phrase and using it to start the next (see, for example, the connections between phrases in bar 8, 18/19 and 20).

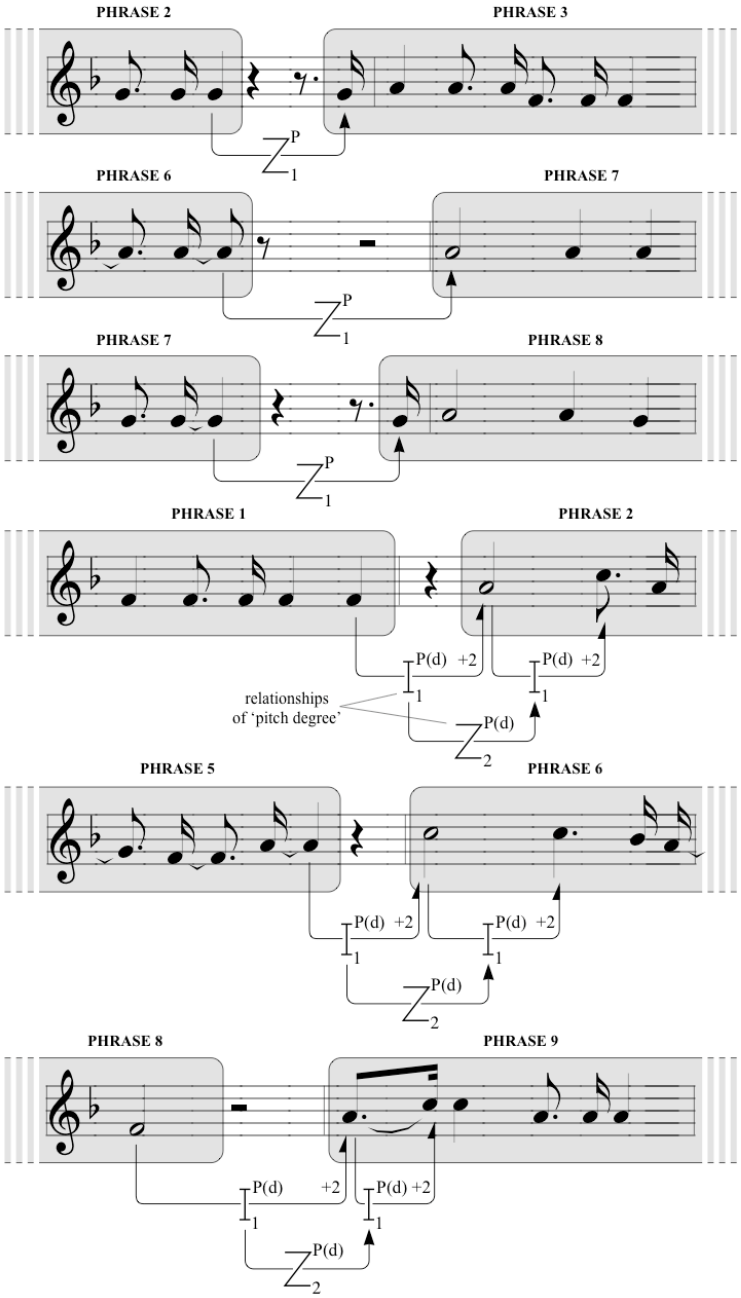


Figure 4

These two approaches to connecting chunks of musical material are typical of many styles (Ockelford, 2004). However, there is another way of linking segments, which involves the repetition (or variation) of chunks *as a whole*. Although, arguably, this is the most widespread of all music-structural techniques, it is not one that K adopts. The nearest she comes to it is in bars 17–24, when a pattern of three descending pitches is successively transposed and varied, mirroring and reinforcing the rhetorical form of the verbal narrative at this point: ('*one* for her biscuits, *one* for her water, and *one* for her meat'). Exact transposition of the intervallic descent, which would have required a Bb at the beginning of bar 19, appears to have been

overwhelmed by K's desire for a convincing concord at this juncture (with the emphasis on the repeated word 'one'). So it is that K demonstrates the intuitive ability to weigh up and manage conflicting musical (and extra-musical) demands, and – in the midst of her improvisation – the capacity to select the option best able to meet her expressive intentions.

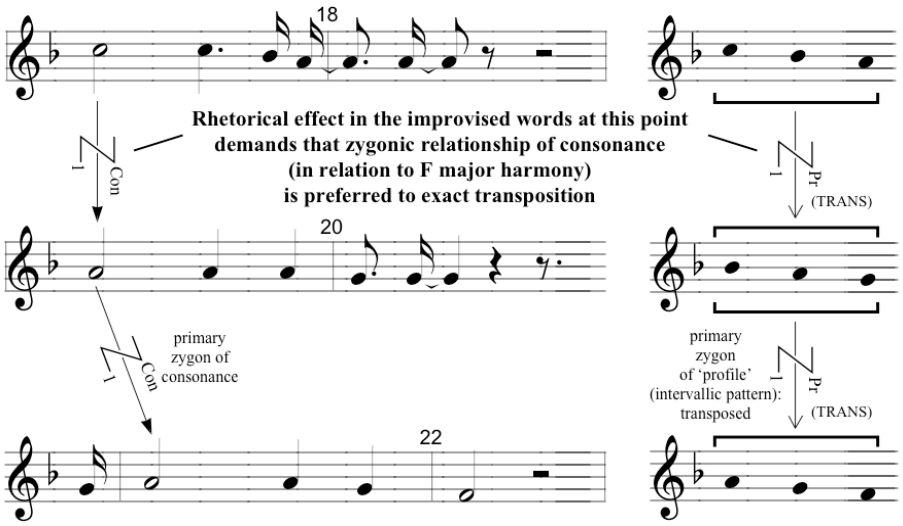


Figure 5

Why does K not make greater use of the commonplace method of repeating or varying chunks as a whole? It may be on account of the improvised nature of the exercise that K was undertaking, in which building a coherent structure depended on remembering material that had just been made up at the same time as continuing with the creative process (which may well have interfered with the memories that had recently been formed). By intuitively adopting the approach of having each successive chunk pick up where the previous one left off, K made fewer demands on her memory and gave herself greater freedom to follow her musical or verbal whim of the moment. A corollary of this free-flowing approach is that there is no particular pattern to the links between chunks in K's song: while the moment-to-moment connections on the musical surface are convincing enough, there is no hierarchical arrangement of the segments – no deeper structural repetition or development. The climax, which occurs at the end of the improvisation, is signaled by a change of register and effected through a high, sustained tonic F (sung *'fortissimo')*, rather than occurring through a feeling of structural inevitability.

Hence, taking all this evidence into account, it is reasonable to assert that K had grasped a number of the key principles of how Western music (within the tonal vernacular of the early 21st century) is structured, and that she was able to use these to create new tunes that would make sense to listeners. We know that K developed this capacity with no formal intervention on the part of others – purely through being exposed to a range of music and through expressing herself by singing. Just as the great majority of people absorb the syntactical rules of their native language without conscious effort (simply by listening and trying things out for themselves), thereby acquiring the ability to create original but coherent and comprehensible linguistic

utterances, so K evidently had done the same in the domain of music. Her intuitive awareness of certain elements of *musical* syntax within familiar styles enabled her to formulate new, stylistically authentic *musical* statements. Of course, this is not in itself exceptional; almost all young children make up songs that are coherent by absorbing, copying and extending what they hear – as infant 'meme engineers' (Barrett, 2003).[xii] It is through considering the way in which the structural techniques that K employed interacted with the accompaniment that was provided that we can glean more about the unusual nature of her developing musicality.

The influence of the accompaniment

Zygonic theory was used to gauge the impact of the accompaniment on K's creative efforts by assessing each note[xiii] in relation to its probable musical sources, which could be found either in AO's melodic opening (bars 1–4), the extemporized piano melody (equivalent to the uppermost RH notes), the bass ostinato or K's vocal line.[xiv] For every note, up to10 zygonic relationships[xv] were considered in relation to pitch, melodic interval, harmonic context and rhythm. These were weighted as follows: pitch scored 2 for exact repetition, and 1 for the transfer of pitch-class to a different octave; melodic interval scored 2 for identity, 1.5 for approximate imitation and 1 for inversion or retrogression; harmonic context scored 2 for exact repetition, 1.5 for variation, 1 for transposition and 0.5 for transposed variation; and rhythm scored 4 for identity, 3 for approximate derivation (including a change of relative location within the relevant metrical level), 2 for repetition of duration or interonset interval only, and 1 where the sole connection was the variation of duration or interonset interval. Since each aspect of every note could be considered to be derived from up to 10 others, further weighting was necessary, whereby each raw score of derivation strength was multiplied by a factor based on the theorized salience of the zygonic relationship concerned, such that the sum of the factors pertaining to the given feature of a particular note was invariably 1.

For example, K's seventh pitch (labeled K7 in Figure 6) could be considered to derive from K6, K5, K4, AM13, K3, K2, AV12, AM11, AV11 and AM10 – the order determined by their temporal adjacency to K7.[xvi] The pragmatic decision was made to separate each of the factors used to moderate the raw scores pertaining to a series such as this by a common difference (implying a linear decrease in the strength of their zygonic influence).[xvii] In this case, with ten factors required, the values used to modify the raw derivation scores were 0.182, 0.164, 0.145, 0.127, 0.109, 0.091, 0.073, 0.055, 0.036 and 0.018 respectively. The result of applying these proportions to the raw scores was a series of 'derivation indices'.

The indices for each feature were summed separately in relation to the material improvised by AO and K. The total potential derivation index for each note ranged between 0 and 10 from either of the two sources (AO or K). With regard to K7, the subtotals pertaining to AO- and K-derived material are show in Figure 6: pitch has a derivation index of 0.618 from AO and 1.382 from K; melodic interval, 0.334 from AO and 1.666 from K; harmonic context, 1.335 from AO and 0.666 from K; and rhythm, 1.620 from AO and 2.136 from K. This yields a total derivation index of 3.907 from AO's material and 5.850 from K's. Given the maximum total derivation index of 10, the sum of these two figures (9.757) leaves a residue of 0.243, reflecting aspects of K7 that cannot be accounted for through derivation from other material in the song. This, then, is a measure of the 'originality' of the event in question (K7) in relation to the improvisation up to that point.[xviii]

Pitch - derived from AO				
event number	*relative position*	*raw score*	*weight factor*	*derivation index*
AM13	4	2	0.127	0.254
AV12	7	2	0.073	0.146
AM11	8	2	0.055	0.110
AV11	9	2	0.036	0.072
AM10	10	2	0.018	0.036
Totals	**5**	**10**	**0.309**	**0.618**

Pitch - derived from K				
event number	*relative position*	*raw score*	*weight factor*	*derivation index*
K6	1	2	0.182	0.364
K5	2	2	0.164	0.328
K4	3	2	0.145	0.290
K3	5	2	0.109	0.218
K2	6	2	0.091	0.182
Totals	**5**	**10**	**0.691**	**1.382**

Interval - derived from AO				
event number	*relative position*	*raw score*	*weight factor*	*derivation index*
AM12	6	2	0.083	0.166
AV12	7	2	0.056	0.112
AM11	8	2	0.028	0.056
Totals	**3**	**6**	**0.167**	**0.334**

Interval - derived from K				
event number	*relative position*	*raw score*	*weight factor*	*derivation index*
K6	1	2	0.222	0.444
K5	2	2	0.194	0.388
K4	3	2	0.167	0.334
K3	4	2	0.139	0.278
K1	5	2	0.111	0.222
Totals	**5**	**10**	**0.833**	**1.666**

Harmonic context - derived from AO				
event number	*relative position*	*raw score*	*weight factor*	*derivation index*
AM9	2	2	0.267	0.534
AV10	3	2	0.200	0.400
AM2	4	2	0.133	0.267
AV4	5	2	0.067	0.134
Totals	**4**	**8**	**0.667**	**1.335**

Harmonic context - derived from K				
event number	*relative position*	*raw score*	*weight factor*	*derivation index*
K6	1	2	0.333	0.666
Totals	**1**	**2**	**0.333**	**0.666**

Rhythm - derived from AO				
event number	*relative position*	*raw score*	*weight factor*	*derivation index*
AV12	4	3	0.133	0.399
AM11	5	3	0.111	0.333
AV8	6	4	0.089	0.356
AM7	7	4	0.067	0.268
AV6	8	4	0.044	0.176
AM5	9	4	0.022	0.088
Totals	**6**	**22**	**0.466**	**1.620**

Rhythm - derived from K				
event number	*relative position*	*raw score*	*weight factor*	*derivation index*
K5	1	4	0.200	0.800
K3	2	4	0.178	0.712
K1	3	4	0.156	0.624
Totals	**3**	**12**	**0.534**	**2.136**

GRAND TOTALS

from AO	'original' material	from K
3.907	0.243	5.850

Figure 6

The usefulness of these figures in interpreting the relationship between AO's and K's contributions lies principally in the ratios between them – taken either as averages over a given period or in terms of event-by-event patterns of variation. For example, the derivation indices for the piece as a whole are as follows.

	AO's material generated from			K's material generated from		
	AO	K	original	AO	K	original
Sum: derivation indices	1827.04	329.60	453.36	369.59	522.77	147.63
Average derivation index	7.00	1.26	1.74	3.55	5.03	1.42

Number of events	261	104

Figure 7

That is to say, 70% of AO's production was generated from other of his material, with a little under 13% deriving from K's input. In contrast, only 50% or so of K's melody is attributable to the emulation of her own efforts, with approximately 36% based on AO's introductory vocal melody and piano accompaniment. This is powerful evidence that, while improvising her own structurally and expressively coherent melody, K was able to attend to the piano accompaniment and (apparently without conscious effort) take on board a range of musical ideas that were presented. Moreover, within the musical interaction that occurred, AO's influence on K was almost three times greater than K's impact on AO – a somewhat sobering statistic for a music educator who at the time felt that he was providing a responsive foil for K's efforts! In fact, zygonic analysis indicates that the flow of musical ideas was largely from teacher to pupil. One wonders how asymmetrical the patterns of influence are in other more 'typical' music-educational and therapeutic contexts, notwithstanding teachers' and therapists' beliefs concerning the child-centredness of their approaches.

The derivation indices also enable us to track how the influence of one performer on another varied over time. For example, during K's first phrase (notes K1–K13), the derivation index from AO's material falls from 9.476 to 0.927, whose trend closely matches a linear descent ($R^2 = 0.8155$) – the principal exceptions being K9 and K10, where K introduces a rhythmic pattern similar to one used in AO's introduction.

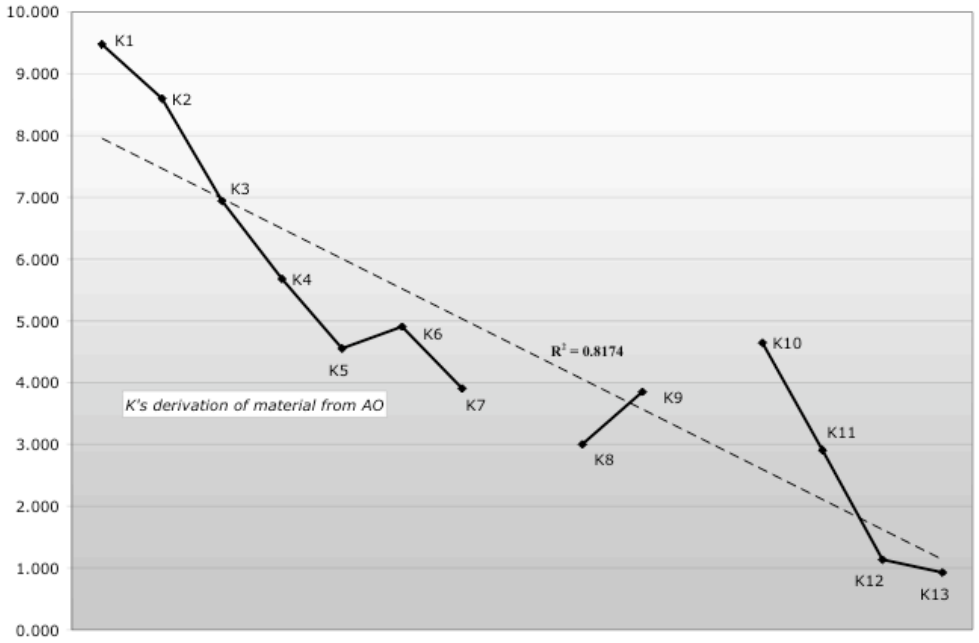
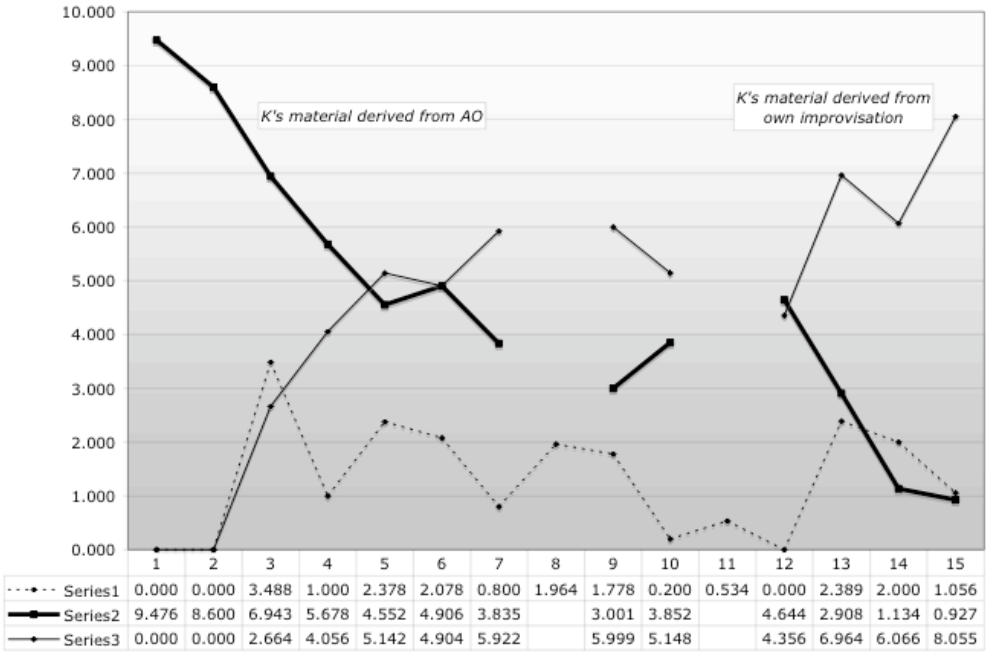


Figure 8

This decline in K's use of AO's material through the phrase reflects K's increasing self-assertion (noted above) and, as one would expect, is matched inversely by an increasing use of her own improvisation to generate further ideas. At the same time, K's use of original material ('Series 3' in the graph) fluctuates at a low level.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Series1	0.000	0.000	3.488	1.000	2.378	2.078	0.800	1.964	1.778	0.200	0.534	0.000	2.389	2.000	1.056
Series2	9.476	8.600	6.943	5.678	4.552	4.906	3.835		3.001	3.852		4.644	2.908	1.134	0.927
Series3	0.000	0.000	2.664	4.056	5.142	4.904	5.922		5.999	5.148		4.356	6.964	6.066	8.055

Figure 9

Subsequent phrases show different derivational patterns that cannot be reported in detail here. However, the mean derivation indices pertaining to phrases will be used to give an overview of trends at a deeper structural level. These show K drawing significantly on A's material in her first phrase, less so in the second, and more again in the third and the fourth. Subsequently, there is a gradual decrease in AO's impact over phrases five to nine – the central part of K's improvisation with the descending sequence at its heart – during which K's efforts become ever more self-sufficient. In contrast, AO's influence is felt more strongly in K's tenth phrase, whose lack of verbal coherence suggests that K may be running out of steam. Indeed, after rallying briefly in the eleventh phrase, K's creative flow almost completely dries up at the beginning of the twelfth, and she draws heavily on material in the accompaniment to sustain her vocal line (although in the concluding notes she finally wrests back the initiative). K's global pattern of derivation from AO, invariably lower than AO's derivation from K, is inversely related to it with a striking consistency (82%). That is to say, during the improvisation, as K chose to rely less on AO for material, AO tended to rely more on K, and *vice versa* – perhaps through an intuitive desire on the part of one performer or both to ensure coherence in the improvised texture as a whole.

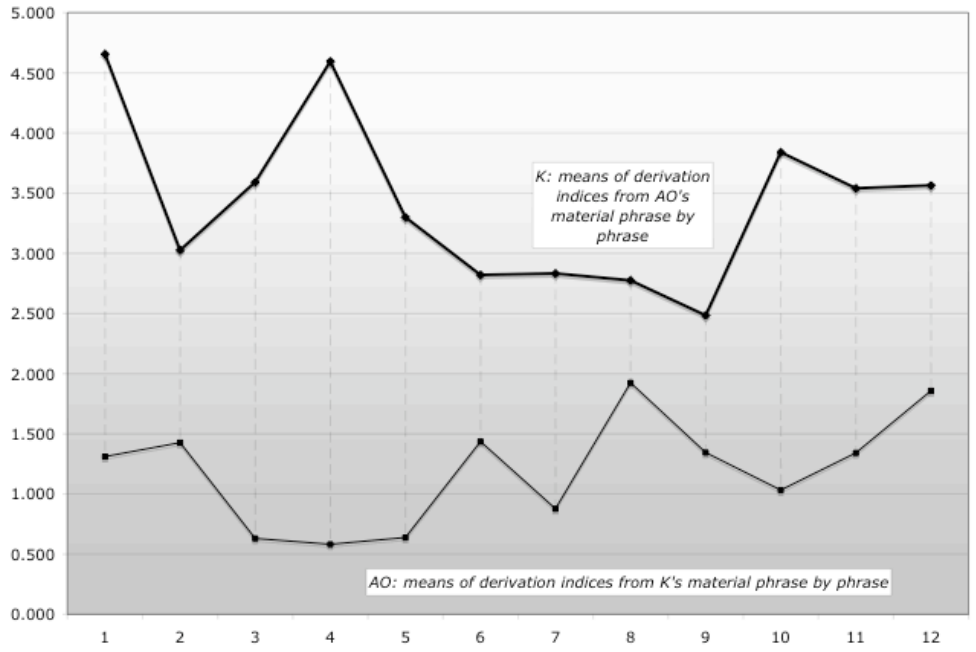


Figure 10

Analysing indices of 'originality' reveals further issues of structural significance. For example, itemizing all K's events that had an originality index ≥ 0.25 (that is, when a quarter or more of material was derived other than from the improvisation) yields 13 entries as follows.

Event	originality	pitch	proportion	interval	proportion	harm. context	proportion	duration	proportion	interonset int.	proportion	Highest
K12	2.800	0.000	**0.000**	0.000	**0.000**	2.000	**0.714**	0.800	**0.286**	0.000	**0.000**	H
K14	6.000	0.000	**0.000**	2.000	**0.333**	1.000	**0.167**	2.000	**0.333**	1.000	**0.167**	H/IOI
K15	5.182	1.000	**0.193**	0.500	**0.096**	1.500	**0.289**	1.126	**0.217**	1.056	**0.204**	H
K17	3.666	0.666	**0.182**	1.500	**0.409**	1.500	**0.409**	0.000	**0.000**	0.000	**0.000**	H/Int
K27	5.400	1.000	**0.185**	1.500	**0.278**	1.500	**0.278**	1.100	**0.204**	0.300	**0.056**	H/Int
K28	2.767	0.382	**0.138**	0.611	**0.221**	0.466	**0.168**	0.654	**0.236**	0.654	**0.236**	D/IOI
K35	2.691	0.000	**0.000**	0.400	**0.149**	1.000	**0.372**	0.601	**0.223**	0.690	**0.256**	H
K49	5.636	2.000	**0.355**	0.000	**0.000**	2.000	**0.355**	0.000	**0.000**	1.636	**0.290**	H
K91	2.657	0.490	**0.184**	0.000	**0.000**	0.167	**0.063**	0.400	**0.151**	1.600	**0.602**	IOIi
K92	3.109	0.399	**0.128**	0.000	**0.000**	2.000	**0.643**	0.710	**0.228**	0.000	**0.000**	H
K94	2.953	0.327	**0.111**	0.472	**0.160**	0.500	**0.169**	0.544	**0.184**	1.110	**0.376**	D
K103	3.346	0.818	**0.244**	0.892	**0.267**	0.000	**0.000**	0.762	**0.228**	0.874	**0.261**	IOI
K104	4.255	0.946	**0.222**	0.309	**0.073**	1.000	**0.235**	2.000	**0.470**	0.000	**0.000**	D
n=13	sum	8.028	1.943	8.184	1.985	14.633	3.863	10.697	2.761	8.920	2.448	
	average	**0.618**	**0.149**	**0.630**	**0.153**	**1.126**	**0.297**	**0.823**	**0.212**	**0.686**	**0.188**	

Figure 11

Although different features are implicated (including melodic interval, duration and interonset interval) K's originality is most frequently expressed in the domain of harmonic context (in 62% of cases). On some occasions, this appears to be a consequence of K's melodic intent overriding the harmony provided (for example, in the second half of bar 6 and at the end of bar 10), although her continuations make sense of these things in retrospect: as we have already observed, the repeated Fs in bar 6 serve as a springboard for the next phrase, while the F at the end of bar 10 is sustained to reach over into the F major harmony that starts the next sequence. However, there are other times when, rather than having arisen as a byproduct of melodic goals, K's harmonic originality seems to have been intrinsically motivated; see, for example, K27, where K's Ab produces an astringent minor 9th chord on the supertonic bass provided. A further measure of K's harmonic creativity can be gleaned from the number of ways in which she melodises a given harmony within the ostinato pattern. For example, K overlays the second chord in the sequence (which in AO's original version comprises a simple D minor harmony – D, F, A) at different times in the course of her improvisation with D, F, G, A, Bb and C, using a range of melodic devices (described below).[xix]

Despite the substantial impact of AO's improvisation on K's melody, the derivation is largely at a 'general' level, whereby each feature almost invariably stems from a number of sources, and the relationships concerned rarely have the salience to stand out from their coherence-creating neighbors and acquire specific structural significance. There are exceptions, however, which function either through a series of relationships working in parallel or by prominent percepts being repeated in temporal apposition. For example, the syncopated rhythm first heard in the piano in bar 12 reappears in the vocal melody in bar 15 (and then again in the piano in bar 24)[xx], while from bar 30, K repeatedly derives Abs and Fs from the accompaniment.

The derivation of material from other sources

The third and final issue to be addressed is the extent to which K uses material from other pieces in her improvisation. For this to occur implies that the music improvised by AO (and by K herself) triggered features common to many other pieces – stylistic influences – that were subsequently pressed into service in the new

work, or specific memories of other compositions, or both. Direct borrowing is not a requirement for musical coherence (although it is encountered widely in traditional jazz – see Berliner (1994, p. 103ff)), and it is not an approach that K adopts.[xxi] The utilization of more general features is far more important in the construction of musically meaningful pieces, however, and K's improvisation does indeed fit comfortably within the stylistic envelope of the Western musical vernacular of the late 20th century, in terms of the tonal and rhythmic frameworks that are used. More than this, though, K utilizes a range of melodic devices that indicate a certain musical sophistication, including passing notes (in bars 15 and 16) and appoggiaturas (see bar 25), as well as elements redolent of the Blues style, in particular the flattened third, first introduced in bar 10.[xxii]

Conclusion

In summary: this paper has analysed a vocal melody improvised by a young girl with septo-optic dysplasia against an ostinato piano accompaniment using a new music-theoretical technique rooted in cognitive science. There are three main areas in which conclusions can be drawn.

First, it appears that the zygonic approach may be of value in interrogating certain aspects of the ebb and flow of musical interaction involving two performers or more. Although labour-intensive at this stage, key elements in this type of analysis could be automated, leaving the researcher to check and refine the data gathered using an appropriate computer programme. The techniques set out in this article could be used more widely to support the assessment of certain aspects of children's music-making informing the aggregation of a bank of comparative data that would enable individual efforts to be contextualized. Clearly, this may be of benefit to music therapists and educationists seeking to evaluate the effect and effectiveness of their interactions with children with disabilities and other special needs. Moreover, as music-analytical techniques such as those used here are further developed, it is interesting to postulate the extent to which the scrutiny of the purely musical elements of an improvisation with two people or more may shed light on aspects of broader personality and human relationships – including the capacity and willingness for imitation, resistance to change, resilience and so on. More broadly, the approach set out here may support the analysis of improvised forms in a range of genres, including jazz.

Second, there are findings of significance in relation to K's evolving musicality. For example, it is evident that, within a familiar style, she can grasp a repeating pattern of harmonies and create material that not only conforms to what is provided but develops and extends it, structurally and expressively. However, there is a lack of thematic correspondence between voice and accompaniment that may have arisen as a consequence of the considerable musical skill and experience that are needed to attend to someone else's contribution and remember it at the same time as creating material oneself. More broadly, the fact that certain common approaches to the logical connection of material are not used and the concomitant absence of a deeper structure may be specific to this improvisation or could indicate where future avenues of K's learning may lie. Although K has evidently achieved a great deal by dint of her own efforts, it is also clear that there is much more that remains to be done, and she would undoubtedly benefit from working with a teacher willing to engage with her musical interests, able to guide her development and with the capacity to work flexibly with her in extending her musical horizons.

Third, there are currently few comparative data available to indicate objectively just how typical or unusual K's improvisation is in relation to what one might reasonably expect from a child of her age – with or without a visual disability – though her ability to construct a mature musical narrative that is at once both expressive and coherent, drawing upon a range of stylistically appropriate music-syntactical techniques, appears to show an exceptional level of musical ability.[xxiii] However, K's efforts should be contextualized in the knowledge that precocious musical talent may well be unusually prevalent in young children with septo-optic dysplasia (Ockelford, 2003; Pring & Ockelford, 2005) and more widely among youngsters with little or no vision (Miller & Ockelford, 2005; Ockelford, Pring, Welch & Treffert, 2005; Ockelford, Welch & Pring, 2005) – irrespective of other disabilities they may have (Ockelford, 1998). K's improvisation supports these and other findings (for example, Ockelford & Pring, 2005; Ockelford, 2007) that the essential elements of advanced musical understanding, many of which are typically conceptualized and codified in the process of music education, can develop and thrive at a purely intuitive level.[xxiv] The enduring message for researchers and teachers alike is the capacity of the mind to absorb and intuitively utilize sophisticated musical strategies with no formal tuition at all.

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[i] Septo-optic dysplasia is a rare condition that occurs in approximately 1 in 16,000 children. It is defined as a combination of optic nerve hypoplasia (absent or small optic nerves), pituitary abnormalities and the absence of the septum pellucidum or corpus callosum or both – without which communication between areas of the mid-brain (such as the transfer of sensory information) is hampered. Among the likely effects of septo-optic dysplasia are visual impairment, hormonal problems, delayed development, behavioral difficulties and obesity. The type and range of symptoms can vary from mild to very severe (Mehta & Dattani, 2004). It is important to note that K is totally blind and does not have delayed development.

[ii] At the time, AO was working as a specialist music teacher in a school for visually impaired children in south London.

[iii] The ability to recognize or reproduce the pitch of notes in isolation from others, which is extremely rare in Western populations as a whole, estimated at only 1 in 10,000 (Takeuchi & Hulse, 1993). Among those born with little or no sight, however, the position appears to be rather different. See, for example, Welch (1988), who found that 22 out of 34 blind children in special schools had AP (65%), and Ockelford (1988), who found that 19 out of 50 children who were born blind or who had lost their sight shortly thereafter had AP (38%). For comparison, Hamilton, Pascual-Leone and Schlaug (2004) reported that 57% of blind musicians within a sample of 21 had AP.

[iv] In the case of K's song, it is important to acknowledge that words were present too, and while these are not the main focus of the discussion here, relevant points will be noted in the context of the musical issues that are identified.

[v] 'Interperspective': a term coined by Ockelford (1991) to mean 'between *perspects'* (that is, *'per*ceived a*spects'*) of music; used in contradistinction to the term 'parameter', which is reserved solely to refer to the physical attributes of sound. Hence the perspect 'pitch', for example, most closely corresponds to the parameter 'frequency', though the connection between the two is far from straightforward (cf. Meyer, 1967, p. 246).

[vi] Observe that arrowheads may be open or filled – the former showing a link between *single* values, and the latter indicating a *compound* connection within or between 'constants' (typically, values extended in time) – implying a network of relationships the same. For a fuller explanation, see Ockelford (1999).

[vii] From the Greek term 'zygon' for 'yoke', implying a union of two similar things.

[viii] It is important to be clear about the status of zygonic relationships. They are *hypothetical constructs* intended to represent aspects of the typically subconscious cognitive processing that can be assumed to occur when we attend to, create or imagine music – a supposition suggested by the structural regularities of pieces, which, as Bernstein asserts, offer 'a striking model of the human brain in action and as such, a model of how we think' (1976, p. 169). Of course, the notion of a zygonic relationship can at best offer only a much-simplified version of certain cognitive events that may be stimulated by participation in musical activity. However, while simplification is necessary to make headway in theoretical terms, it is important to bear in mind that the single concept of a zygon bequeaths a substantial perceptual legacy, with many possible manifestations, not only potentially linking individual pitches, timbres, dynamics, durations and interonset intervals, but also prospectively existing between tonal regions, textures, processes and forms the same; over different periods of perceived time; functioning reactively or proactively; and within the same and between different pieces, performances and hearings. Given this variety, there is, of course, no suggestion that the one concept represents only a single aspect of cognitive processing. Hence, empirical evidence in support of the theory is likely to be drawn from a diversity of sources. Currently, for example, one can point to experiments in auditory processing (such as the 'continuity illusion', summarised in Bregman, 1990, p. 344ff) and work on expectation in a musical context, particularly that involving the perceptual restoration of omitted or obscured notes (for instance, DeWitt & Samuel, 1990), to support the presence of proactive zygonic-type processes (Ockelford, 1999, p. 123; 2006a). There is general support for the theory too in the wide range of music-theoretical and analytical sources in which the fundamental importance of repetition in music is acknowledged. These are itemized in Ockelford (1999). Similar acknowledgements are made by Borthwick (1995), as a background to the exposition of his metatheoretical framework to which the notions of identity (and non-identity) are central. Perhaps most pertinent of these to zygonic theory is the assertion of Cone (1987, p. 237), made in relation to the derivation of musical material, that 'y is derived from x (y ← x), or, to use the active voice, x generates y (x →y), if y resembles x and y follows x. By "resembles", I mean "sounds like" …'.

[ix] That is not to say that, in order to be coherent, K's improvisation should consist only of repetition. Through 'perceptual binding' (the cognitive glue through which the different properties of an object cohere in the mind to form the notion of a single thing – see, for example, Snyder (2000, p. 7)) and *Gestalt* perception (through which discrete events are reckoned to form larger wholes – see, for instance, Deutsch (1999)) sounds, or groups of sounds, may differ from each other in some respects while being the same in others. Hence (as we shall see), similarity and diversity work in parallel in the creation of musical material that is at once original though coherent.

[x] Fuller presentations of data and their analysis are available in electronic form from the author.

[xi] See also Figure 2.

[xii] See also, for example, Moog (1976, pp.128–133, Hargreaves (1985, pp. 60ff), Barrett (2006).

[xiii] Hence the analysis was as fine-grained as it was practicable to make it. Longer pieces could be investigated using more substantial musical gestures as the primary unit of analysis.

[xiv] This work was undertaken by AO, utilizing his intuitions as an experienced music analyst, performer and educator. The principal disadvantage of this approach was the possibility of bias through idiosyncratic interpretation of the underlying structural relationships. The advantage was his intimate knowledge of the situation in question – in particular what was going through his mind as the accompanist. Future analyses along these lines could (though need not) be based more on the consensus of a number of people's views. Indeed, it is anticipated that a significant proportion of the analytical activity could be undertaken by computer (searching for combinations of similarity and salience through appropriate algorithms).

[xv] Chosen for pragmatic reasons – other analyses could involve more or fewer relationships per feature than this.

[xvi] On the grounds that, other things being equal, their temporal adjacency corresponds to their relative salience and therefore implicative strength. Factors that could impact on this assumption include the possibility of an event pertaining to a larger perceptual unit. Hence it is thought that the bass note at the beginning of bar 5 (third octave F), for example, more strongly derives from the bass notes at the beginning of bars 3 and 1 respectively than the temporally more adjacent Fs in the vocal and piano melody lines (something that is reinforced through common and differing octaves respectively).
[xvii] Future analyses could adopt different approaches.
[xviii] The issue of material derived from other pieces is considered briefly in the third section of the analysis.
[xix] Similarly, while K's phrase-lengths indicate her evident cognizance of the underlying harmonic structure, they are not bound by it, ranging in duration from two beats to nine. Here, the influence of the improvised words appears to have been particularly important. Moreover, in the manner of a mature musical dialogue, K sometimes left the piano to play on its own (notably in bars 11 and 12), partly to regroup her own thinking, no doubt, though nonetheless affording a convincing feeling of 'give and take'.
[xx] The extent to which AO derives material from K (for example in bars 28 and 35) will be the subject of a separate investigation which seeks to gauge the balance of influence between the two parties, and where the locus of control lies at any given point (Ockelford & Pring, forthcoming).
[xxi] AO does, however, quoting *Dream, Dream, Dream* by the Everly Brothers in bars 20–23.
[xxii] Although this is hinted at by AO in bars 5 and 6.
[xxiii] The extent to which her verbal improvisation is typical, both in its own right and in relation to the music, are the potential subjects of future research.
[xxiv] K also shows us that, contrary to certain thinking, it is not necessary to know to the names of notes to possess AP. For a discussion of a range of issues related to our current understanding of AP, see Deutsch, Henthorn and Dolson (2004)